along vein 4. Outer margin with an irregular band from costa to vein 3, and separated from first discal line from costa to vein 6 by a yellowish line with black dots proximally of it on veins 6, 7, and 8. A submarginal row of seven black spots and a dot in cellule 8 at apex. Fringes dark at ends of veins. Hind wing without markings, except a black spot at anal angle and a small tuft of black hair below it.

Underside.—Fore wing chrome-yellow, darker beyond cell and over apical third; three black dots, the first the largest, in cellules 7, 6, and 5. Hind wing without markings.

Antennæ with black dot at base on vertex, prothorax, and patagia marked with chestnut-brown, the latter with fringe tipped with black; a small tuft of black hair at base of abdomen; tarsi black.

♀. Similar to ♂, with paler brownish markings and discal lines more heavily marked.

Length of fore wings, ♂ ♀, 27 mm.

Types from Angi Lakes, Arfak Mountains, 6000 feet, N. New Guinea, Jan. to Feb. 1914. 2 ♂ ♂ and 1 ♀ were obtained.

EXPLANATION OF PLATE XII.

Fig. 1. *Milionia rubrifascia*, ♀.
Fig. 2. —— *rubra*, ♀.
Fig. 3. —— *xanthica*, ♀.
Fig. 4. —— ——, ab. *bipuncta.*
Fig. 5. —— ——, ab. *extensa.*
Fig. 6. —— *knowlei*, ♂.
Fig. 7. —— *weiskei rubidifascia*, ♂.
Fig. 8. *Eubordeta albifascia*, ♂.
Fig. 9. *Craspedopsis angiana*, ♂.
Fig. 10. *Buzara calodesma latimargo*, ♀.
Fig. 11. *Parabasis felixi*, ♂.

XXV.—*Upper Silurian Foraminifera of Gothland.*

By John Smith.

[Plate XIII.]

Previous Knowledge of the Palæozoic Foraminifera.

We are pretty well acquainted with the Carboniferous Foraminifera, so well depicted in Brady's "Monograph," published by the Palæontographical Society in vol. xxx.

In strata lower than the Carboniferous few species have hitherto been found.

In quartzites etc. of pre-Cambrian age in Brittany very minute things have been got, globular or nearly so, spiny and perforated, sometimes in strings, the largest only the $\frac{1}{250}$ of an inch in diameter (Ann. Soc. Géol. Nord, vol. xxii.).

Ehrenberg, in 1858, figured five genera from the blue clay of the Baltic provinces, a horizon now known to belong to the Lower Cambrian. They are glauconite casts referable to the genera *Nodosaria*, *Rotalina*, and *Pulvinulina*.

Foraminifera have been recorded from the Cambrian system of Siberia (Q. J. G. S. vol. lvi.) and from the Saint John Series of New Brunswick (Tr. N. Y. Acad. of Sci. vol. xii. for 1893).

In the Q. J. G. S. for 1900 Chapman has figured and described nine species of Foraminifera from the Upper Cambrian in the Malverns. They have all been drawn from polished specimens of the rock, and comprise the genera *Spirillina*, *Lagena*, *Nodosaria*, *Marginulina*, and *Cristellaria*. Chapman, in this paper, says :—"Foraminifera are, however, rare at the best until the lower limestones of the Carboniferous period are reached."

Above the Bala Limestone of Guildfield, near Welshpool, Foraminifera have been got (Geol. Mag. 1882).

Chapman, in his 'Foraminifera,' p. 254, says that in the Llandovery beds of Cwm Symlog *Dentalina*, *Textularia*, and *Rotalia*? have been got, and, at p. 255, *Hyperammina* and *Stacheia* were got in Gotland; he also adds that Vine's Silurian genus *Psammosiphon* has been relegated to the genus *Stacheia*.

Brady, in 1888, figured four species of *Lagena* from the Upper Silurian of England, and I supplied him with some of the specimens (Geol. Mag. for 1888).

Four species have been got in the Upper Silurians of Indiana, and casts from the Devonian of Paffrath, referable to the genera *Lagenulina*, *Cristellaria*, *Orbulina*, *Globigerina*, and *Fusulina*.

Gothland Upper Silurian Foraminifera.

To the casual visitor to Gothland the rocks present but two petrographical series—a great limestone-bed, and under it a rather thicker shale-bed with limey bands and nodules more or less through it, the whole being contained within 240 feet of thickness. In the south of the island there is sandstone under a thick limestone, and on this point there is a division of opinion, the minority, following Murchison, holding the notion that there is an ascending series towards

the south, so that the limestone of Hoburgen—the extreme southern part—is on a higher horizon than that of the rest of the island, and the majority that the sandstone simply occupies so much of the space taken up by the shale in the north. As opinions are not evidence, the proof, one way or the other, will not be obtained till a bore is put down on the Hoburg shore.

The Foraminifera recorded in this paper were obtained, one species from the lower part of the limestone, and the rest from the shales towards their upper part.

Horizons.

The Gothland strata range from the *Monograptus*-shales (under the Llandovery) to the Downtonian (above the Ludlow *).

The species got in the limestone may be referred to the Aymestry, and the rest to the Wenlock horizon of England.

Foraminifera (Remarks on the Species).

All the specimens figured are from plump and solid individuals, none from cut sections of the rock, and, unless otherwise stated, are enlarged 40 diameters.

To Mr. Joseph Wright, F.G.S., of Belfast, who has devoted a large part of his lifetime to the study of the Foraminifera, I am indebted for piloting me through this labyrinth of small things. I make this early reference to him, as I will have frequently to bring in his name in connection with some of the species. I am also indebted to him for many of the references.

Hyperammina vagans, Brady.

Girvanella problematica, N. & E.

At the time (1878) Nicholson and Ederidge published their first fasciculus of the Girvan fossils, they gave an excerpt of a letter from Brady, this letter pointing out that *G. problematica* resembled *H. vagans*, a present-day species, and this has been sustained by later investigators. "*Girvanella*" is common in Gothland, so much so that two series of strata have been called "*Girvanella*-zones." This fossil has, however, to be mostly determined from cut bits of the rock; but from the shales I got a number of specimens showing the

* Dr. Munthe's Memoir on the Strata of Southern Gothland (in English).

entire tubes twisting in every direction. The illustration I give is a portion of a small mass, and would have been more complete but for the shale, which more or less covers the tubes.

Loc. Muldé and Fröjel.

Hyperammina minutissima, sp. n.

From its minute size and rough surface, Mr. Wright thinks this form may be made a new species. This little fossil is attached to a spicule, the figure showing about a third of it magnified 1000 diameters.

Loc. Wisby Cement Works.

Hyperammina rectangula, sp. n.

This is also a branching form, and the two figures will show how the branches go off at nearly right angles. Both figures show the primordial cell (also seen in living specimens of *H. vagans*), one of them with a ring. The dimensions are given in Explanation of Plate (p. 309).

Loc. Muldé and Fröjel.

From the Gothland shales I have obtained a series of *Hyperammina*, ranging in size between the largest and smallest species given above, and several "species" might easily be made from them; but as they are smooth and follow more or less the character of *H. vagans*, they may be placed with that species.

Hyperammina ramosissima, Chap.

The figure will show the branching-habit of this species, a feature from which it takes its specific name.

Loc. Gothem.

Reoplax pilulifera, Brady.

The specimen is probably incomplete, shows three loculiments with very distinct perforations.

Loc. Korpklint.

Reoplax adunca, Brady.

This is a rare species.

Loc. Sleté.

Haplophragmium latidorsatum, Born, sp.

Loc. Gothem.

Ammodiscus gordialis, J. & P., sp.

Only one specimen got.
Loc. Korpklint.

Trochammina anceps, Brady.

There was only one got, and it occurred in decayed crystalline limestone.
Loc. Kappelshamn, near the shore.

Webbina cf. *hemispherica*, J., P., & B.

This species is constantly attached to shells etc., but, being uniformly of a brownish colour, I thought it might be a macrospore. Dr. Kidston, however, will not express an opinion on it. Mr. Wright thinks it may be a *Webbina* flattened by pressure. I had never any doubt about the flattening. In appearance it is either a flat cake or like a shallow saucer with a slightly raised rim.
Loc. Röfvar Liljas hålo and Sleté.

Webbina gothemensis, sp. n.

Occurs as a thin-edged cake on other fossils, the surface swelling up irregularly as shown on figure.
Loc. Gothem.

Stacheia acervalis, Brady.

Not abundant, but pretty widely spread and attached to other organisms, and on account of this differs greatly in appearance.
Loc. Stora Carlsö, Muldé, and Lau Canal. Common in the Carboniferous rocks of Scotland.

Stacheia congesta, Brady.

The two figures will show the extreme variations of shape.
Loc. Muldé, Fröjel, Wisby Cement Works, Lummelunds Bruk. Common in the Carboniferous limestones and shales of Scotland.

Lagena globosa, Montag., sp.

This species differs greatly in size and shape, sometimes all but globular, others long-oval, and in cross-section not always round. They can be distinguished by their colour, a light grey. The five illustrations are each from different specimens:

a, view of aperture; *b*, *c*, undersides. Some of the shapes are identical to those assumed by the little freshwater Rhizopod of our ponds and ditches called *Difflugia*.

Loc. Lau Canal, Sluguklint, Korpklint, Stora Carlsö.

Lagena lævis, Montag., sp.

The two figures give the extreme variation in shape seen.

Loc. Lau Canal and Sluguklint.

Lagena clavata, D'Orb., sp.

The two figures show the extreme of variation.

Loc. Sluguklint.

Lagena gracillima, Seg., sp.

The two figures show considerable differences in shape, but not any more so than recent forms.

Loc. Wisby Cement Works.

Lagena parkeriana, Brady.

The seven figures I give of this species will show how it varies in shape and size.

Loc. Stora Carlsö, Lau Canal, Röfvar Liljas hälo, and Sluguklint. Common in the Carboniferous limestones of Scotland.

Lagena auriculata, var. *linearituba*, Cushman.

I had regarded this form as a *Fusulina*, but Mr. Wright has no doubt of its being a *Lagena*.

Loc. Wisby Cement Works.

Lagena cylindrica, sp. n.

This species is all but cylindrical, with the neck of the tube sometimes slightly bent.

Loc. Stora Carlsö and Wisby Cement Works.

Lagena gottlandica, sp. n.

Globular, with a short tube.

This form differs from all recorded species of Foraminifera in having minute concentric striæ, resolvable by high powers into beaded lines running round the test. As wasted specimens it is not infrequent, but when perfect it is a bright glittering little form.

Loc. Stora Carlsö.

Lagena gutta *, sp. n.

Like the above, this one has got surrounding striæ, but differs in being oval and apiculate.

Loc. Fröjel.

Lagena storavedensis, sp. n.

Like the two last, this one has also got striæ running round the shell. In shape it comes pretty near to some of the forms of *L. parkeriana*.

Loc. Stora Vedé.

Lagena visbeyensis, sp. n.

This form is apiculate, with a long tube, and has got four to six strongly pronounced rounded costæ.

Loc. Wisby Cement Works.

Lagena acutangula, sp. n.

This one has got a strong resemblance to *L. gracillima*, but has five sharp-edged costæ.

Loc. Wisby Cement Works.

Nodosaria cf. *soluta*, Rss.

The figure in the 'Challenger' Monograph has seven loculiments; the one figured here has only three, but is probably imperfect.

Loc. Stora Vedé.

Nodosaria inflexa, Rss., sp.

The two figures will show the extreme varieties of shape.

Loc. Wisby Cement Works and Sluguklint.

Nodosaria siluriana, sp. n.

Resembles *N. inops*, Rss., but differs in having sharp costæ with deep spaces between them.

Loc. Wisby Cement Works.

Orbulina universa, D'Orb.

This is not a common form in the Gothland shales, but its minute size may cause it to be overlooked.

Loc. Stora Carlsö.

* Gutta was the poetical name of Odin.

GOTHLAND UPPER SILURIAN FORAMINIFERA, SHOWING THEIR RANGE IN TIME.

	Cambrian.	Upper Silurian, Gothland.	Carboniferous.	Recent.
Hyperammina vagans, *Brady*	..	*	*	*
—— minutissima, sp. n.	..	*		
—— rectangula, sp. n.	..	*		
—— ramosissima, *Chap.*	..	*		
Reoplax pilulifera, *Brady*	*	*	..	*
—— aduncа, *Brady*	*	*	..	*
Haplophragmium latidorsatum, *Born.*, sp.	*	*	..	*
Ammodiscus gordialis, *J. & P.*, sp.	*	*	*	*
Trochammina anceps, *Brady*	..	*	*	
Webbina hemisphærica, *J., P., & B.*	*	*	..	*
—— gothemensis, sp. n.	..	*		
Stacheia acervalis, *Brady*	..	*	*	
—— congesta, *Brady*	..	*	*	
Lagena globosa, *Montag.*, sp.	*	*	*	*
—— lævis, *Montag.*, sp.	*	*	*	*
—— clavata, *Montag.*, sp.	*	*	*	*
—— gracillima, *Seg.*, sp.	*	*	..	*
—— parkeriana, *Brady*	..	*	*	
—— auriculata, var. linearituba, *Cushman*	..	*	..	*
—— cylindrica, sp. n.	..	*		
—— gottlandica, sp. n.	..	*		
—— gutta, sp. n.	..	*		
—— storavedensis, sp. n.	..	*		
—— visbyensis, sp. n.	..	*		
—— acutangula, sp. n.	..	*		
Nodosaria *cf.* soluta, *Rss.*, sp.	*	*	..	*
—— inflexa, *Rss.*, sp.	*	*	..	*
—— siluriana, sp. n.	..	*		
Orbulina universa, *D'Orb.*	..	*	..	*

Abstract.

Recent	13 species.
Carboniferous	8 „
Upper Silurian	29 „
Cambrian	11 „

The whole of the Cambrian species are got living at the present day.

New species, ten. Species hitherto known from the Upper Silurian, seven.